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(continued on next page)

(54) Abstract Title: Coupling an expandable liner to a wellbore casing

(57) A method couples a tubular liner 250 to a cased section 110 within a wellbore 100, where the wellbore includes an uncased section proximate the cased section. The method is suitable where the wellbore traverses a porous subterranean formation 120, and the operating pressure of the wellbore is greater than the operating pressure of the subterranean zone. The method comprises positioning the liner 250 and an expansion cone 220 within the wellbore; overlapping a portion of the liner with the cased section; and radially expanding the liner using the expansion cone. An equal distribution of expansion stresses is applied to the interior surface of the portion of the liner that does not overlap with the cased section of the wellbore. The expansion cone may be actuated by increasing fluidic pressure within the liner region 275 or may be characterised by an expansion cone launcher 230 including a shoe 240 and valveable passage 245. The system mitigates any tendency for the liner to adhere to under-pressurised sections of the formation.

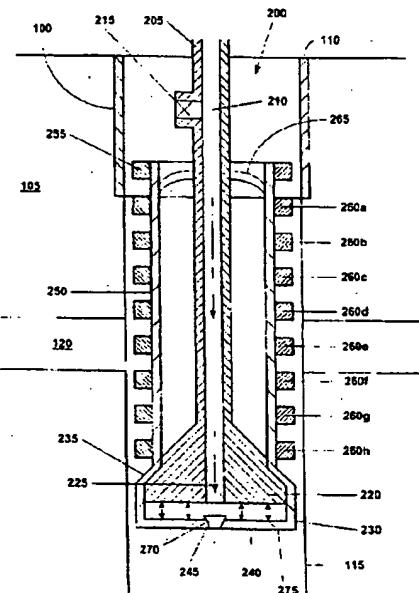


FIGURE 5

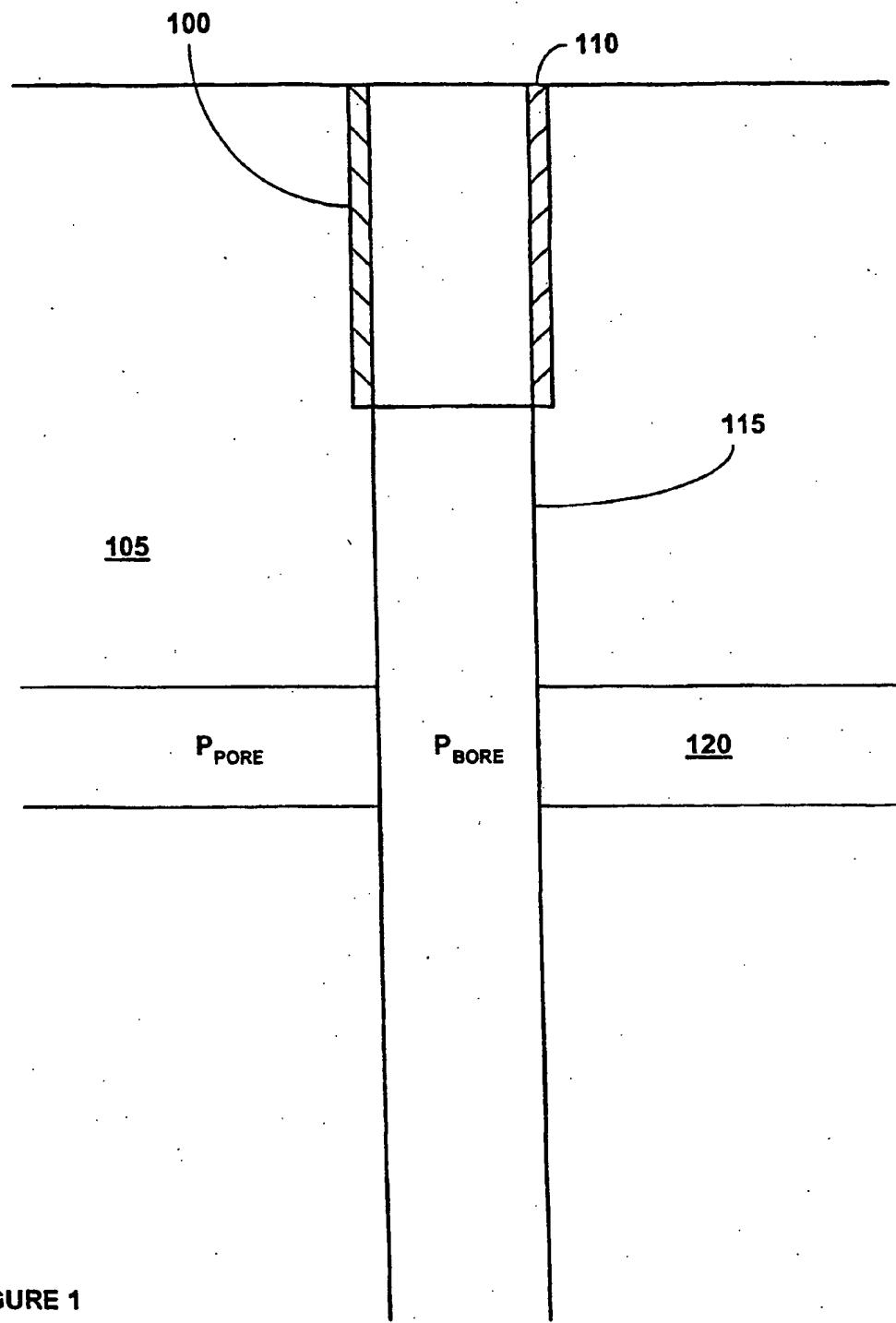
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**GB 2400624 A continuation**

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**FIGURE 1**

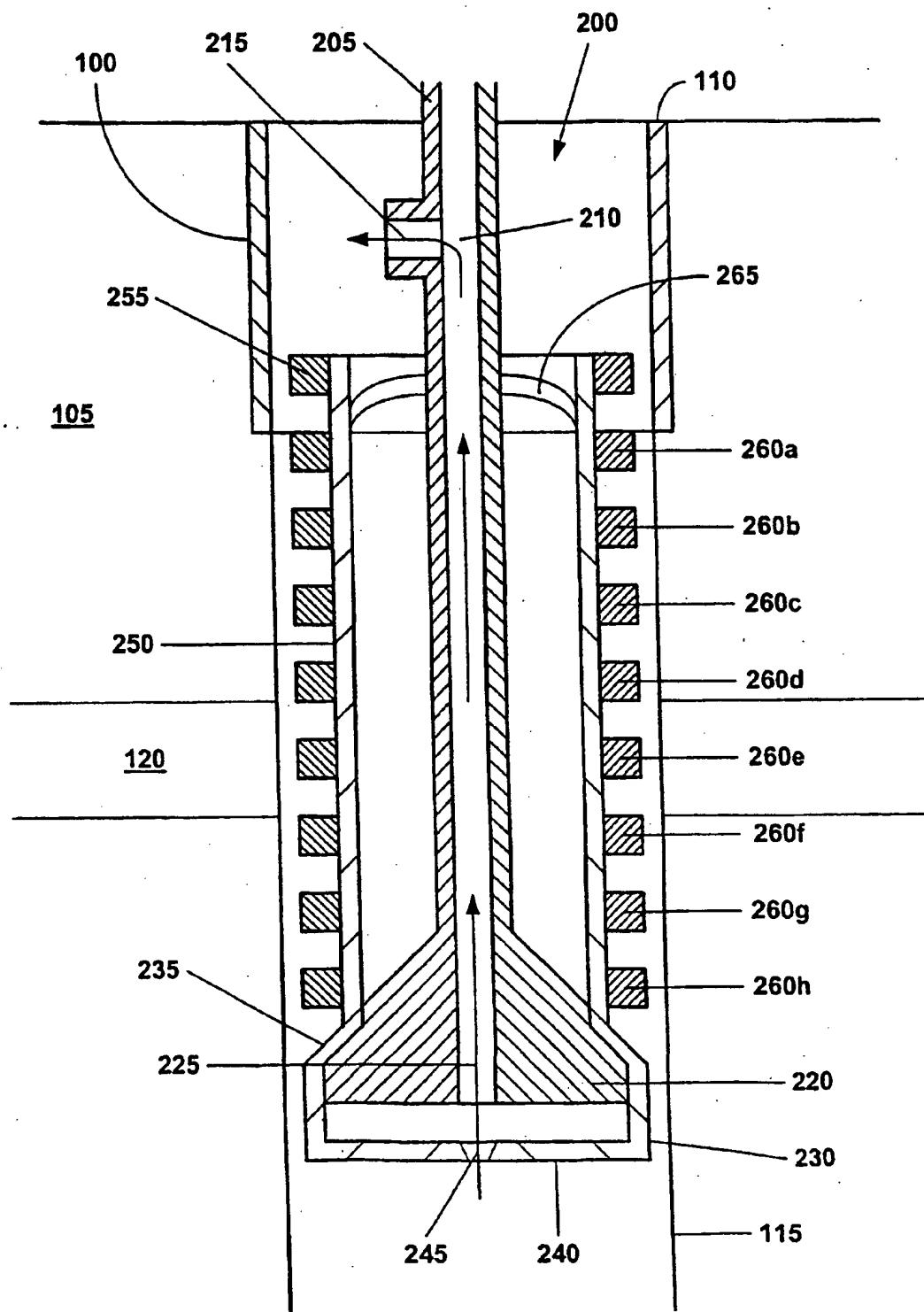


FIGURE 2

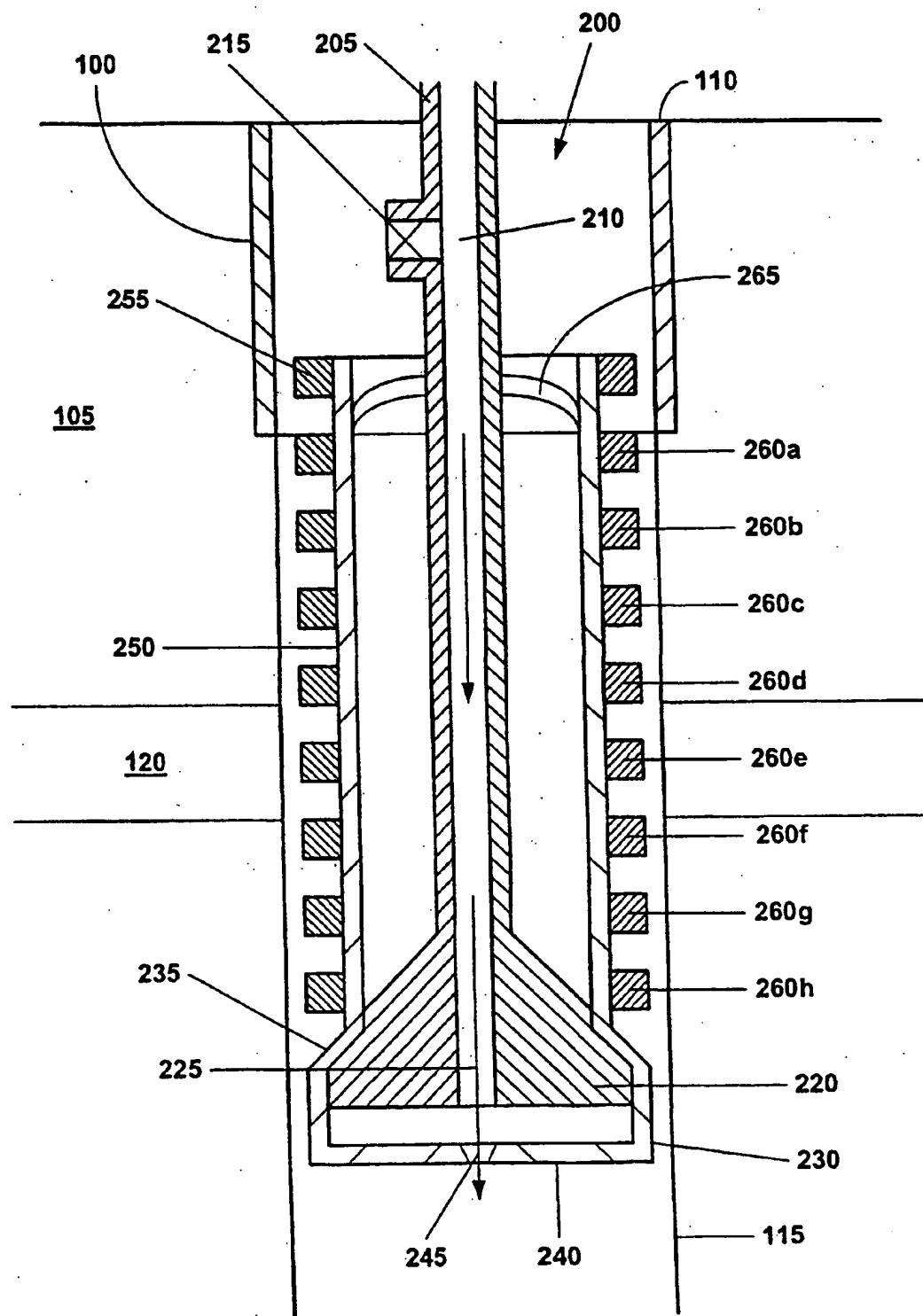


FIGURE 3

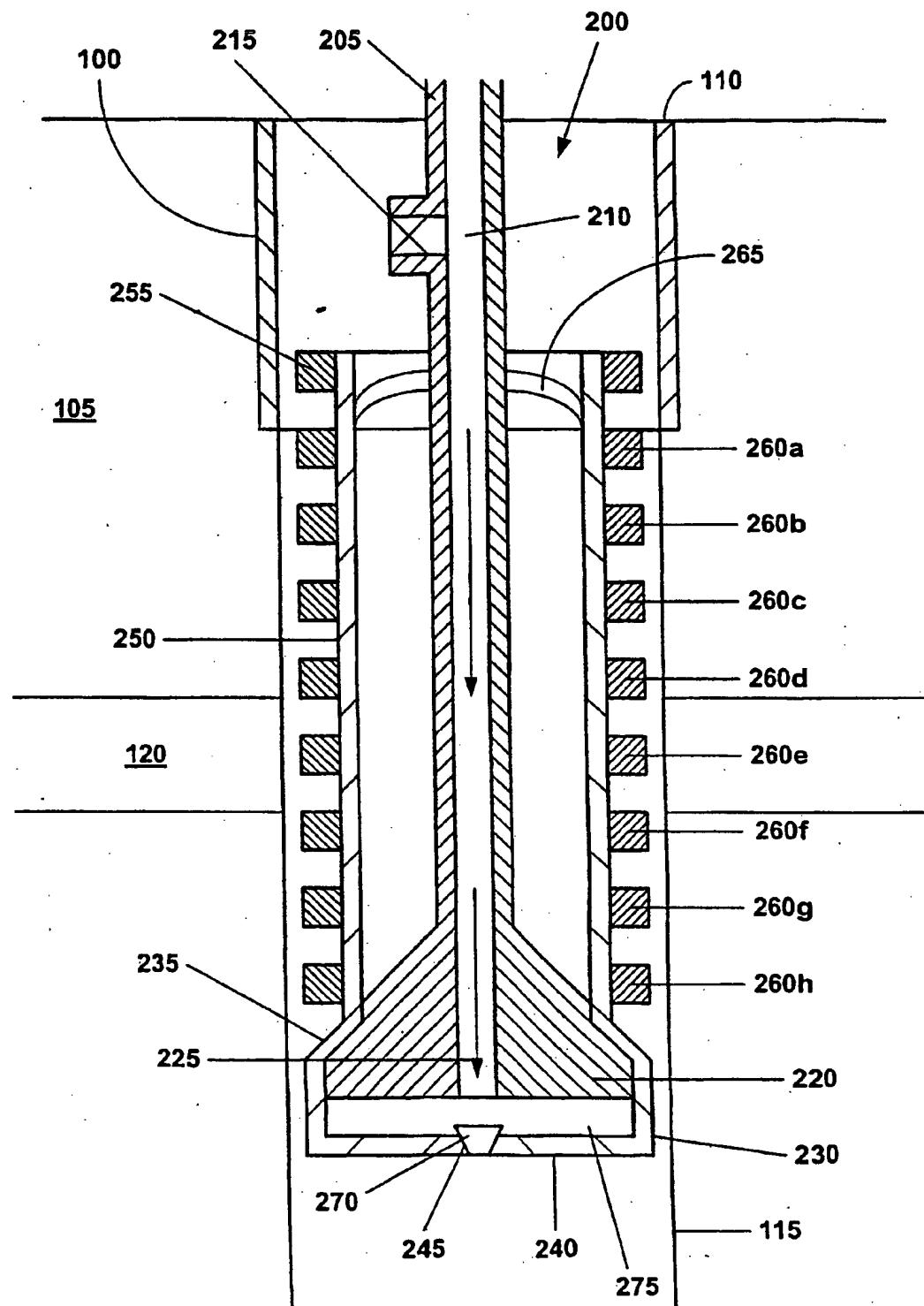


FIGURE 4

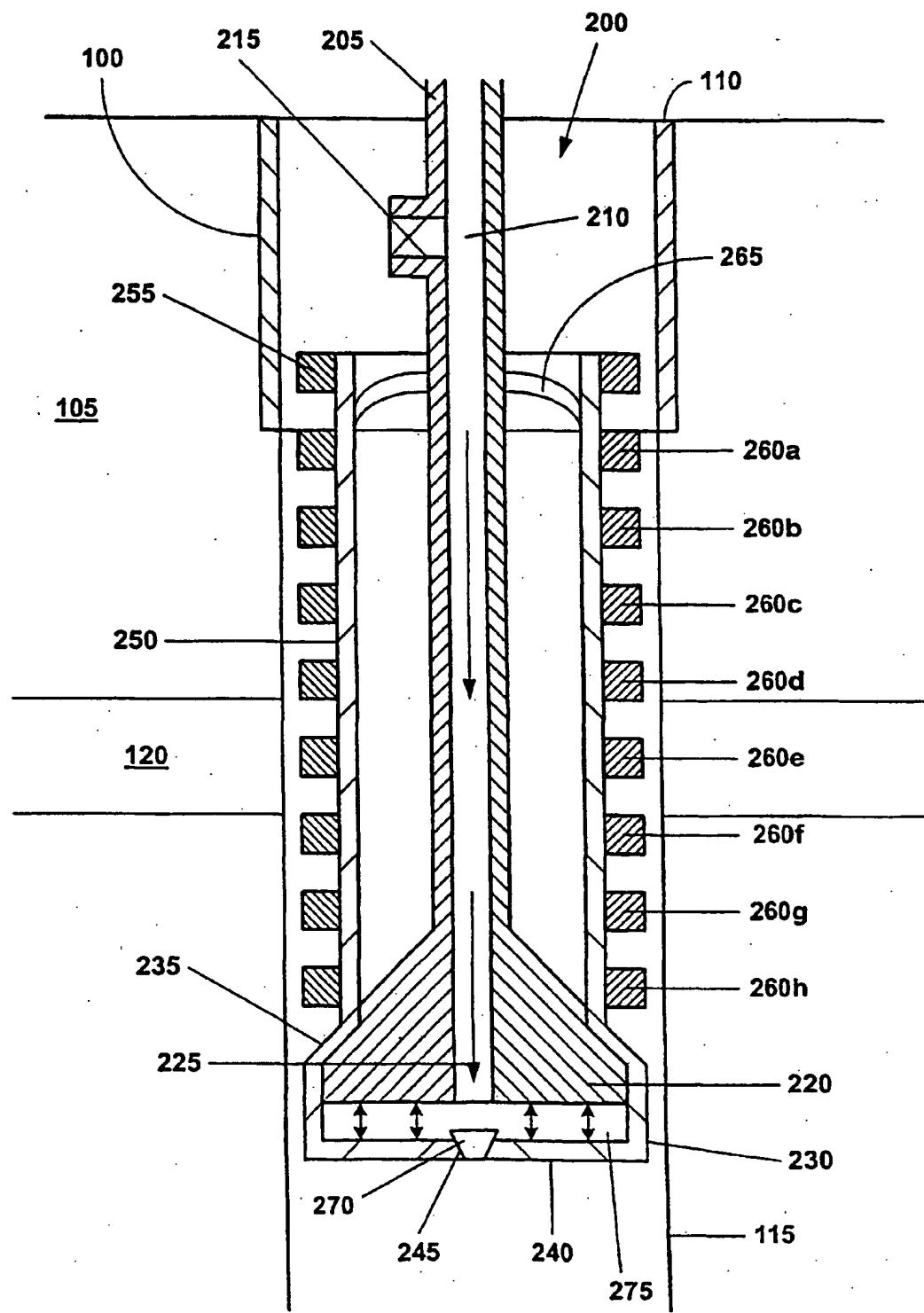


FIGURE 5

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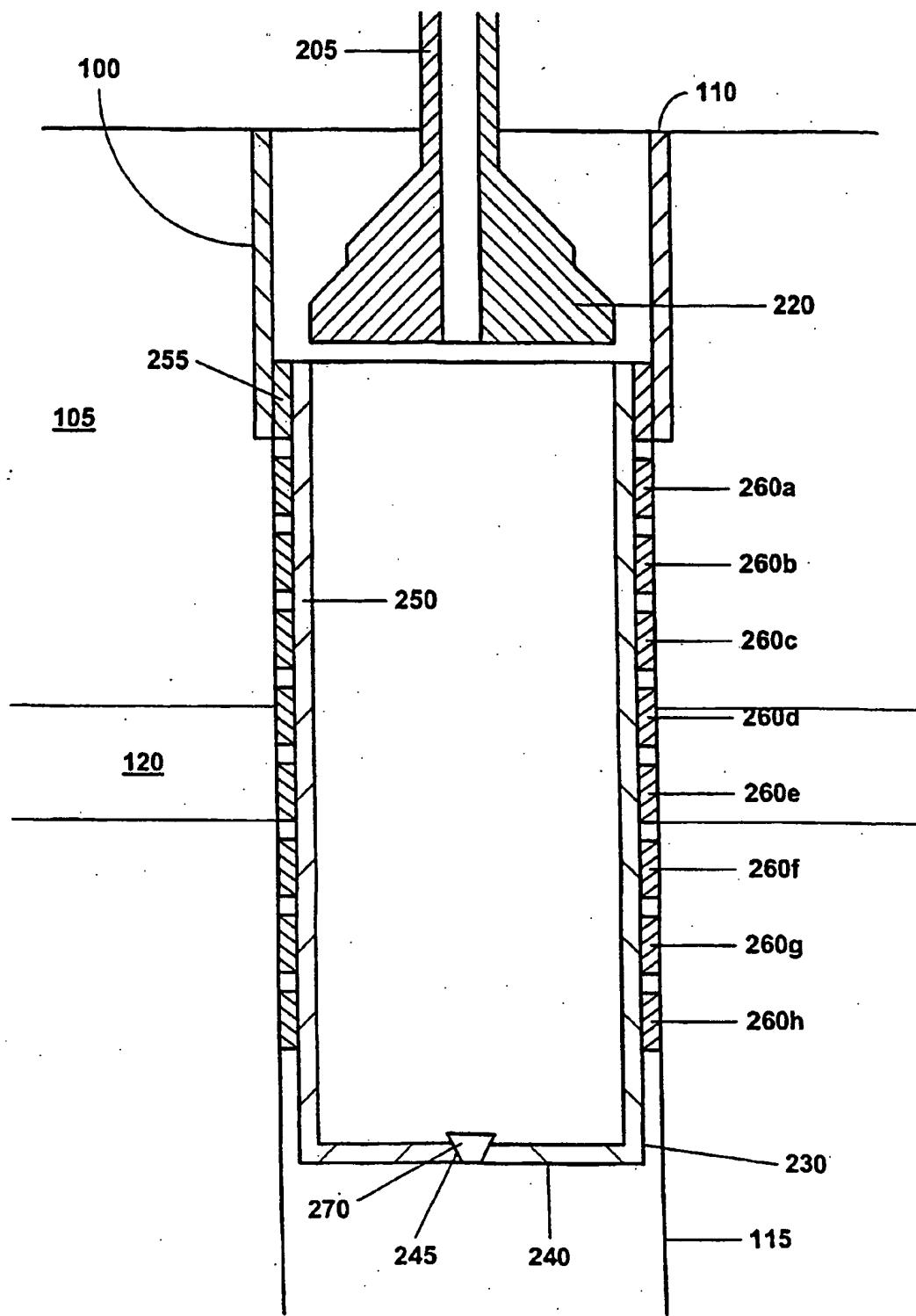


FIGURE 6

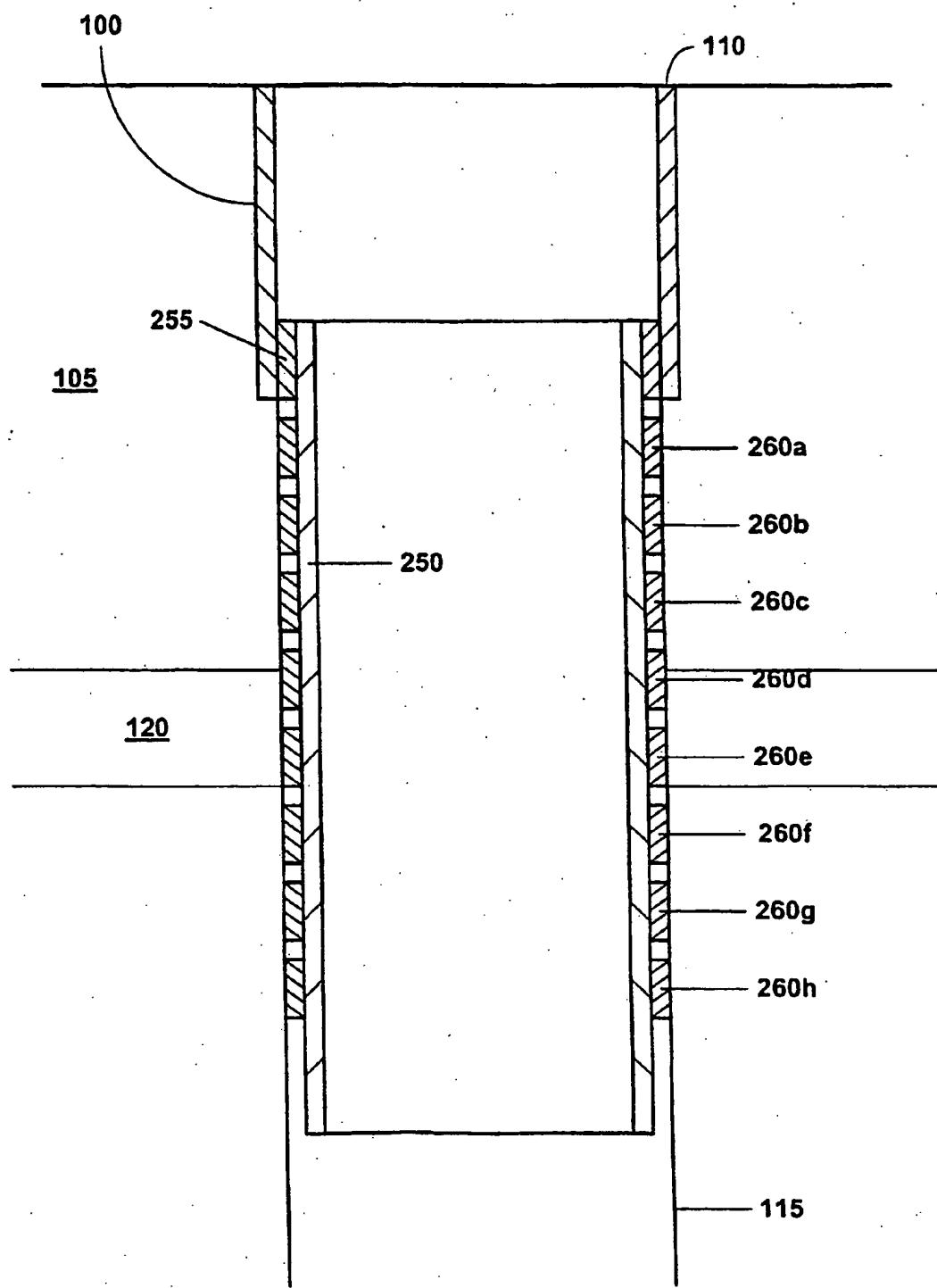


FIGURE 7

LINER HANGER WITH STANDOFFS  
Cross Reference To Related Applications

This application claims the benefit of the filing date of U.S. provisional patent application serial number 60/221,645, attorney docket number 25791.46, filed on 5 7/28/2000, the disclosure of which is incorporated herein by reference.

This application is related to the following co-pending applications: (1) U.S. patent application serial no. 09/440,338, attorney docket number 25791.9.02, filed on 11/15/1999, which claimed benefit of the filing date of U.S. provisional patent application serial number 60/108,558, attorney docket number 25791.9, filed on 10 11/16/1998, (2) U.S. patent application serial no. 09/454,139, attorney docket number 25791.3.02, filed on 12/3/1999, which claimed benefit of the filing date of U.S. provisional patent application serial number 60/111,293, filed on 12/7/1998, (3) U.S. patent application serial number 09/502,350, attorney docket number 25791.8.02, filed on 2/10/2000, which claimed the benefit of the filing date of U.S. provisional patent 15 application serial number 60/119,611, attorney docket number 25791.8, filed on 2/11/1999, (4) U.S. patent application serial number 09/510,913, attorney docket number 25791.7.02, filed on 2/23/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/121,702, attorney docket number 25791.7, filed on 2/25/1999, (5) U.S. patent application serial number 09/511,941, 20 attorney docket number 25791.16.02, filed on 2/24/2000, which claimed the benefit of the filing date of U.S. provisional patent application number 60/121,907, attorney docket number 25791.16, filed on 2/26/1999, (6) U.S. patent application serial number 09/523,460, attorney docket number 25791.11.02, filed on 3/10/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 25 60/124,042, attorney docket number 25791.11, filed on 3/11/1999, (7) U.S. patent application serial number 09/559,122, attorney docket number 25791.23.02, filed on 4/26/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/131,106, attorney docket number 25791.23, filed on 4/26/1999, (8) U.S. patent application serial number \_\_\_\_\_, attorney docket 30 number 25791.17.02, filed on \_\_\_\_\_, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/137,998, attorney docket number 25791.17, filed on 6/7/1999, (9) U.S. provisional patent application serial number 60/143,039, attorney docket number 25791.26, filed on 7/9/1999, (10) U.S. provisional patent application serial number 60/146,203, attorney docket number

25791.25, filed on 7/29/1999, the disclosures of which are incorporated by reference; (11) U.S. provisional patent application serial number 60/183,546, attorney docket number 25791.10, filed on 2/18/2000; (12) U.S. patent application serial number 09/512,895, attorney docket number 25791.12.02, filed on 2/24/2000, which claimed  
5 the benefit of the filing date of U.S. provisional patent application serial number 60/121,841, attorney docket number 25791.12, filed on 2/26/1999; (13) U.S. provisional patent application serial number \_\_\_\_\_, attorney docket number 25791.38, filed on 6/19/2000; (14) U.S. provisional patent application serial number 60/162,671, attorney docket number 25791.27, filed on 11/1/1999; (15) U.S. provisional patent  
10 application serial number 60/159,039, attorney docket number 25791.36, filed on 10/12/1999; (16) U.S. provisional patent application serial number 60/159,033, attorney docket number 25791.37, filed on 10/12/1999; (17) U.S. provisional patent application serial number 60/165,228, attorney docket number 25791.39, filed on 11/12/1999; and  
15 (18) U.S. provisional patent application number \_\_\_\_\_, attorney docket number 25791.45, filed on \_\_\_\_\_, the disclosures of which are incorporated herein by reference..

#### Background of the Invention

This invention relates generally to wellbore casings, and in particular to wellbore casings that are formed using expandable tubing.  
20 Conventionally, when a wellbore is created, a number of casings are installed in the borehole to prevent collapse of the borehole wall and to prevent undesired outflow of drilling fluid into the formation or inflow of fluid from the formation into the borehole. The borehole is drilled in intervals whereby a casing which is to be installed in a lower borehole interval is lowered through a previously installed casing of an upper borehole interval. As a consequence of this procedure the casing of the lower interval is of  
25 smaller diameter than the casing of the upper interval. Thus, the casings are in a nested arrangement with casing diameters decreasing in downward direction. Cement annuli are provided between the outer surfaces of the casings and the borehole wall to seal the casings from the borehole wall. As a consequence of this nested arrangement  
30 a relatively large borehole diameter is required at the upper part of the wellbore. Such a large borehole diameter involves increased costs due to heavy casing handling equipment, large drill bits and increased volumes of drilling fluid and drill cuttings. Moreover, increased drilling rig time is involved due to required cement pumping.

cement hardening, required equipment changes due to large variations in hole diameters drilled in the course of the well, and the large volume of cuttings drilled and removed.

The present invention is directed to overcoming one or more of the limitations of  
5 the existing procedures for forming wellbores and wellheads.

#### Summary of the Invention

According to one aspect of the present invention, a method of forming a casing in a wellbore having a cased section and an open hole section is provided that includes positioning a tubular liner within the wellbore, overlapping the tubular liner and the  
10 cased section, centering the tubular liner within the wellbore, and radially expanding the tubular liner into contact with the cased section.

According to another aspect of the present invention, a radially expandable tubular member for repairing an opening in a wellbore casing is provided that includes a tubular member, and one or more standoffs coupled to the exterior surface of the  
15 tubular member.

According to another aspect of the present invention, an apparatus for repairing an opening in a wellbore casing is provided that includes a tubular support member including a first passage, an expansion cone coupled to the tubular support member including a second passage fluidically coupled to the first passage, an expansion cone launcher coupled to the expansion cone including a shoe having an exhaust passage, and an expandable tubular member coupled to the expansion cone launcher including  
20 one or more standoffs.

According to another aspect of the present invention, an apparatus is provided that includes a wellbore including a preexisting casing and an open hole section, and a  
25 radially expanded tubular member coupled to the preexisting casing including one or more standoffs.

#### Brief Description of the Drawings

FIG. 1 is a cross-sectional view illustrating a wellbore including a wellbore casing and an open hole section that traverses a porous subterranean layer.

30 FIG. 2 is a fragmentary cross-sectional view illustrating the introduction of an apparatus for casing the open hole section of the wellbore of FIG. 1.

FIG. 3 is a fragmentary cross-sectional view illustrating the injection of a fluidic material into the apparatus of FIG. 2.

FIG. 4 is a fragmentary cross-sectional view illustrating the placement of a plug into the exhaust passage of the shoe of the apparatus of FIG. 3.

FIG. 5 is a fragmentary cross-sectional view illustrating the pressurization of the interior portion of the apparatus below the expansion cone of FIG. 4.

5 FIG. 6 is a fragmentary cross-sectional view illustrating the completion of the radial expansion of the tubular member of the apparatus of FIG. 5.

FIG. 7 is a fragmentary cross-sectional view illustrating the removal of the shoe from the apparatus of FIG. 6.

#### Detailed Description of the Illustrative Embodiments

10 An apparatus and method for casing an open hole section of a wellbore within a subterranean formation is provided. The apparatus and method provides a system for casing an open hole section of a wellbore within a subterranean formation in which a tubular member having a plurality of radially oriented standoffs is radially expanded into contact with the preexisting wellbore casing and the open hole section. The 15 standoffs provided on the exterior surface of the tubular member preferably position the tubular member away from the interior walls of the open hole section during the radial expansion process. In this manner, the tubular member does not adhere to underpressurized sections of the open hole section of the wellbore. In this manner, the process of radial expansion is more reliable.

20 Referring initially to Fig. 1, a wellbore 100 positioned within a subterranean formation 105 includes a preexisting casing 110 and an open hole section 115 that traverses an porous region 120. When the operating pressure within the wellbore  $P_{BORE}$  is greater than the operating pressure within the porous region  $P_{PORE}$ , fluidic materials will flow from the wellbore 100 into the porous region 120. As a result of the 25 flow of fluidic materials from the wellbore 100 into the porous region 120, downhole equipment will tend to adhere to, or at least be drawn toward, the interior surface of the wellbore 100 in the vicinity of the porous region 120. This can have serious and adverse consequences when radially expanding a tubular member in such an operating environment.

30 Referring to Fig. 2, an apparatus 200 for forming a wellbore casing in the open hole section of the wellbore 100 may then be positioned within the wellbore in an overlapping relationship with the lower portion of the preexisting wellbore casing 110.

The apparatus 200 includes a tubular support member 205 having a longitudinal passage 210 and a transverse passage 215 that is coupled to an expansion cone 220 having a longitudinal passage 225 that is fluidically coupled to the longitudinal passage 210. The expansion cone 220 is at least partially received within

5 an expansion cone launcher 230 that includes a thin-walled annular member 235 and a shoe 240 having an exhaust passage 245. An expandable tubular member 250 extends from the expansion cone launcher 230 that includes a sealing member 255 and a plurality of standoffs 260a-260h affixed to the exterior surface of the expandable tubular member. In a preferred embodiment, the standoffs 260 are fabricated from a

10 resilient material. A sealing cup 265 is attached to the exterior surface of the tubular support member 205 for preventing foreign materials from entering the interior of the expandable tubular member 250.

In a preferred embodiment, the apparatus 200 is provided as disclosed in one or more of the following: (1) U.S. patent application serial no. 09/440,338, attorney docket number 25791.9.02, filed on 11/15/1999, which claimed benefit of the filing date of U.S. provisional patent application serial number 60/108,558, attorney docket number 25791.9, filed on 11/16/1998, (2) U.S. patent application serial no. 09/454,139, attorney docket number 25791.3.02, filed on 12/3/1999, which claimed benefit of the filing date of U.S. provisional patent application serial number 60/111,293, filed on 12/7/1998, (3) U.S. patent application serial number 09/502,350, attorney docket number 25791.8.02, filed on 2/10/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/119,611, attorney docket number 25791.8, filed on 2/11/1999, (4) U.S. patent application serial number 09/510,913, attorney docket number 25791.7.02, filed on 2/23/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/121,702, attorney docket number 25791.7, filed on 2/25/1999, (5) U.S. patent application serial number 09/511,941, attorney docket number 25791.16.02, filed on 2/24/2000, which claimed the benefit of the filing date of U.S. provisional patent application number 60/121,907, attorney docket number 25791.16, filed on 2/26/1999, (6) U.S. patent application serial number 09/523,460, attorney docket number 25791.11.02, filed on 3/10/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/124,042, attorney docket number 25791.11, filed on 3/11/1999, (7) U.S. patent application serial number 09/559,122, attorney docket number 25791.23.02, filed on

4/26/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/131,106, attorney docket number 25791.23, filed on 4/26/1999, (8) U.S. patent application serial number \_\_\_\_\_, attorney docket number 25791.17.02, filed on \_\_\_\_\_, which claimed the benefit of the filing 5 date of U.S. provisional patent application serial number 60/137,998, attorney docket number 25791.17, filed on 6/7/1999, (9) U.S. provisional patent application serial number 60/143,039, attorney docket number 25791.26, filed on 7/9/1999, (10) U.S. provisional patent application serial number 60/146,203, attorney docket number 25791.25, filed on 7/29/1999, the disclosures of which are incorporated by reference; 10 (11) U.S. provisional patent application serial number 60/183,546, attorney docket number 25791.10, filed on 2/18/2000; (12) U.S. patent application serial number 09/512,895, attorney docket number 25791.12.02, filed on 2/24/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/121,841, attorney docket number 25791.12, filed on 2/26/1999; (13) U.S. provisional 15 patent application serial number \_\_\_\_\_, attorney docket number 25791.38, filed on 6/19/2000; (14) U.S. provisional patent application serial number 60/162,671, attorney docket number 25791.27, filed on 11/1/1999; (15) U.S. provisional patent application serial number 60/159,039, attorney docket number 25791.36, filed on 10/12/1999; (16) U.S. provisional patent application serial number 60/159,033, attorney 20 docket number 25791.37, filed on 10/12/1999; and (17) U.S. provisional patent application serial number 60/165,228, attorney docket number 25791.39, filed on 11/12/1999, the disclosures of which are incorporated herein by reference.

As illustrated in Fig. 2, during placement of the apparatus 200 within the wellbore 100, fluidic materials displaced by the apparatus 200 are conveyed through 25 the longitudinal passages 210 and 225 to the transverse passage 215. In this manner, surge pressures during the placement of the apparatus 200 within the wellbore 100 are minimized. Furthermore, as illustrated in Fig. 2, the apparatus 200 is preferably initially positioned with upper portion of the tubular member 250 in opposing relation to the lower portion of the preexisting wellbore casing 110. In this manner, the upper portion 30 of the tubular member 250 may be radially expanded into contact with the lower portion of the preexisting wellbore casing 110. In a preferred embodiment, during the placement of the apparatus 200 within the wellbore 100, the standoffs 260a-260h prevent the apparatus 200 from adhering to, or being drawn toward, the interior surface

of the wellbore 100 in the vicinity of the porous region 120. In this manner, the apparatus 200 is approximately centered within the wellbore 100.

As illustrated in Fig. 3, the transverse passage 215 may then be closed and fluidic materials injected into the apparatus 200 through the longitudinal passage 210.

5 In this manner, any blockages within any of the passages 210, 225, and 245 may be detected by monitoring the operating pressure whereby an increase in operating pressure above nominal, or predetermined, conditions may indicate a blockage of one of the passages.

As illustrated in Fig. 4, a plug 270 or other conventional stop member may then  
10 be introduced into the fluidic materials injected into the apparatus 200 through the passage 210, and the plug 270 may be positioned within the exhaust passage 245. In this manner, the exhaust passage 245 may be sealed off. Thus, continued injection of fluidic materials into the apparatus 200 through the passage 210 may thereby pressurize a region 275 below the expansion cone 220.

15 As illustrated in Figs. 5 and 6, continued pressurization of the region 275 causes the expansion cone 220 to radially expand the expandable tubular member 250 off of the expansion cone. In this manner, the upper portion of the radially expanded tubular member 250 is coupled to the lower portion of the preexisting wellbore casing 110. In a preferred embodiment, during the radial expansion process, the tubular  
20 support member 205 is raised out of the wellbore 100.

In a preferred embodiment, throughout the radial expansion process, the standoffs 260a-260h prevent the exterior surface of the apparatus 200 from adhering to, or being drawn toward, the interior surface of the wellbore 100 in the vicinity of the porous region 120. In this manner, the apparatus 200 is preferably substantially  
25 centered within the wellbore 100. Furthermore, in this manner, the longitudinal center axis of the expansion cone 220 is preferably maintained in a position that is substantially coincident with the longitudinal center axis of the tubular member 250. In addition, in this manner, the stresses applied to the interior surface of the tubular member 250 by the axial displacement of the expansion cone 220 are substantially  
30 even. Finally, in this manner, overstressing of the tubular member 250 is prevented thereby eliminating catastrophic failure of the tubular member 250.

As illustrated in Fig. 7, the shoe 240 may then be removed using a conventional milling device.

In a preferred embodiment, upon radially expanding the expandable tubular member 250, the standoffs 260a-260h seal and isolate intervals within the open hole section 115. In several alternative embodiments, the standoffs 260 may be provided, for example, by annular members spaced along the length of the expandable tubular member 250 and/or a continuous member that is wrapped around the expandable tubular member 250 in helical fashion.

5

It is understood that variations may be made in the foregoing without departing from the scope of the invention. For example, the apparatus 200 may be used to form and/or repair, for example, a wellbore casing, a pipeline, or a structural support.

10        Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. In some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent  
15        with the scope of the invention.

Claims

1. In a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a method of coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:
  - positioning a solid tubular liner and an expansion cone within the wellbore;
  - overlapping a portion of the solid tubular liner with the wellbore casing;
  - radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion cone relative to the solid tubular liner; and
  - during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing, applying substantially equal stresses to the interior surface of the portion of the solid tubular liner that does not overlap with the wellbore casing using the expansion cone proximate the porous subterranean zone.
2. In a wellbore that traverses a subterranean formation, the wellbore including a cased section having a wellbore casing and an uncased section that traverses a porous subterranean zone, wherein the operating pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, a system for coupling a tubular liner to the wellbore casing of the cased section of the wellbore, comprising:
  - positioning a solid tubular liner and an expansion cone within the wellbore;
  - overlapping a portion of the solid tubular liner with the wellbore casing;
  - radially expanding the solid tubular liner by injecting a fluidic material into the tubular liner to pressurize the interior of the solid tubular liner and displace the expansion cone relative to the solid tubular liner; and
  - during the radial expansion of the portion of the solid tubular liner that does not overlap with the wellbore casing proximate the porous subterranean zone, applying substantially equal stresses to the interior surface of the portion of the solid tubular liner that does not overlap with the wellbore casing using the expansion cone.
3. An apparatus for coupling a tubular liner to a wellbore casing within a wellbore that traverses a porous subterranean formation, wherein the operating

pressure of the wellbore is greater than the operating pressure of the porous subterranean zone, comprising:

- a tubular support member defining a first internal passage;
- an expansion cone coupled to the tubular support member defining a second
- 5   internal passage fluidically coupled to the first internal passage;
- a tubular expansion cone launcher movably coupled to and mating with the expansion cone;
- a tubular liner coupled to an end of the tubular expansion cone launcher; and
- a shoe coupled to another end of the tubular expansion cone launcher including
- 10   a valveable passage; and

means for during a radial expansion of a portion of the solid tubular liner that does not overlap with the wellbore casing, applying substantially equal stresses to the interior surface of the portion of the solid tubular liner that does not overlap with the wellbore casing using the expansion cone.

15

1. A method of forming a casing in a wellbore having a cased section and an open hole section, comprising:
  - 5 positioning a tubular liner within the wellbore;
  - overlapping the tubular liner and the cased section;
  - centering the tubular liner within the wellbore; and
  - radially expanding the tubular liner into contact with the cased section.
2. The method of claim 1, wherein centering comprises:
  - 10 preventing the tubular liner from adhering to the open hole section of the wellbore.
3. A radially expandable tubular member for repairing an opening in a wellbore casing, comprising:
  - 15 a tubular member; and
  - one or more standoffs coupled to the exterior surface of the tubular member.
4. An apparatus for repairing an opening in a wellbore casing, comprising:
  - 20 a tubular support member comprising a first passage;
  - an expansion cone coupled to the tubular support member comprising a second passage fluidically coupled to the first passage;
  - an expansion cone launcher coupled to the expansion cone comprising a shoe having an exhaust passage; and
  - 25 an expandable tubular member coupled to the expansion cone launcher comprising one or more standoffs.
5. An apparatus, comprising:
  - 30 a wellbore comprising a preexisting casing and an open hole section; and
  - a radially expanded tubular member coupled to the preexisting casing comprising one or more standoffs.
6. A system for forming a casing in a wellbore having a cased section and an open hole section, comprising:

means for positioning a tubular liner within the wellbore;  
means for overlapping the tubular liner and the cased section;  
means for centering the tubular liner within the wellbore; and  
means for radially expanding the tubular liner into contact with the cased  
5 section.

7. The system of claim 6, wherein the means for centering comprises:  
means for preventing the tubular liner from adhering to the open hole section of  
the wellbore.

10



INVESTOR IN PEOPLE

**Application No:** GB0416834.0

**Examiner:** Alan Jones

**Claims searched:** 1-3

**Date of search:** 10 August 2004

### **Patents Act 1977: Search Report under Section 17**

#### **Documents considered to be relevant:**

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-3	GB2344606 A (SHELL INT RESEARCH) See whole document
X	1-3	US6085838 A (VERCAEMER ET AL) See e.g. figs 5-7

#### **Categories:**

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application

#### **Field of Search:**

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC<sup>W</sup>:

E1F

Worldwide search of patent documents classified in the following areas of the IPC<sup>07</sup>

E21B

The following online and other databases have been used in the preparation of this search report

Online: WPI, EPODOC, PAJ